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INTERFACE REQUIREMENTS DOCUMENT (IRD)

FOR THE

GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE SERIES R (GOES-R) SYSTEM

SPACE SEGMENT (SS) TO EMERGENCY MANAGERS WEATHER INFORMATION NETWORK (EMWIN)

Document No.
417-SeriesR-IRD-0004

January 10, 2005

GOES-R PROJECT OFFICE
NASA GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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CHANGE RECORD PAGE

DOCUMENT TITLE: IRD for the GOES-R System SS to EMERGENCY MANAGERS WEATHER INFORMATION NETWORK (EMWIN)
DOCUMENT DATE January 10, 2005

ISSUE	DATE	PAGES AFFECTED	DESCRIPTION
Original	07/25/03	All pages affected	Rev D1 (Draft) for review.
Draft 2	1/10/2005	All pages affected	Rev D2 (Draft) for review

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1.0 INTRODUCTION

The Geostationary Operational Satellite System Series R (GOES-R) is an operational mission to make observations from geostationary orbit. The GOES-R mission will provide an Advanced Baseline Imager (ABI), Hyperspectral Environmental Suite (HES), Space Environmental In-Situ Suite (SEISS), Solar Imaging Suite (SIS), Geostationary Lightning Mapper (GLM), and auxiliary communication services described below. The five GOES-R mission segments that interface and function to support the total GOES-R mission are described below. The bold titles are items that are covered in this IRD.

- **Space Segment (SS)**
- Ground Located – Command, Control, and Communications Segment (GL-C3S)
- Product Generation and Distribution Segment (PGDS)
- User Interface Segment (UIS)
- Archive Segment (AS)

As part of the Space Segment (SS), the GOES-R will support the following NOAA auxiliary communication services:

- GOES Rebroadcast (GRB) Service
- Low Rate Information Transmission (LRIT) Service
- **Emergency Managers Weather Information Network (EMWIN) Service**
- Data Collection System (DCS)
- Search and Rescue (SAR) Service

1.1 Purpose

The purpose of this document is to describe and specify the functional and performance interface requirements for the communication links between the GOES-R Space Segment (SS) and the Emergency Management Weather Information Network (EMWIN).

This document it also intended to provide a basis for the subsequent development of a SS-EMWIN Interface Control Document (ICD) by the spacecraft contractor.

1.2 Scope

The interfaces addressed in this document support the flow of data between the SS and the EMWIN ground segments. Therefore a complete characterization of the EMWIN links depends on the detailed process of onboard reception and retransmission. Only those parameters, which are necessary to specify the interface requirements, will be referenced in this IRD. This IRD therefore:

- Identifies required RF links between the SS and the EMWIN ground segment.
- Establishes functional and performance requirements related to these links.

1.3 Applicable Documents

The following documents of the issue listed, or of the issue in effect on the effective date of the contract, form a part of this IRD to the extent specified herein. In the event of conflict between documents specified herein and other detailed content of this IRD, this IRD shall be the superseding requirement.

[1] Mission Requirements Document 2B (MRD-2B) for the GOES-R Series, Version 1.0 dated December 13, 2004.

[2] NOAA/NESDIS Antennas and RF System Capabilities Handbook, NOAA/OSD3-2001-0043R0UD0, 10 August 2001

[3] ITU-R P618-8 Propagation data and prediction methods for the design of Earth-space telecommunications systems

[4] ITU-R P837-4 Characteristics of precipitation for propagation modeling

[5] ITU-R P676-5 Attenuation by atmospheric gases

[6] ITU-R P839-3 Rain height model for prediction methods

[7] ITU-R P838-2 Specific attenuation model for rain for use in prediction methods

[8] ITU-R P581-2 The concept of the worst month

[9] ITU-R P679-3 Propagation data required for the design of broadcasting-satellite systems

[10] ITU-R P841-3 Conversion of annual statistics to worst-month statistics

[11] ITU-R P531-7 Ionospheric propagation data and prediction methods required for the design of satellite services and systems

[12] International Telecommunications Union (ITU) Recommendation ITU-R RA 769-1 of the 1998 Edition of the ITU Regulations for Radio Astronomy

[13] ITU Article S21 of the ITU Radio Regulations RR-S21 described in the 2001 Edition of the ITU Regulations for Power Flux Density

[14] National Telecommunications and Information Administration “Manual of Regulations and Procedures for Federal Radio Frequency Management”, May 2003 Edition, September 2004 Revision

Discussion: The ITU documents described in references [3] thru [12] can be used in determining propagation attenuation. Reference [9] is for scintillation loss. The dash number used for each document is the updated release number. The web site for the ITU documents is http://www.itu.int/publibase/catalog/index.asp Additional information about the EMWIN Subsystem is available on the Internet NOAA Web page at http://iwin.nws.noaa.gov/emwin/index.htm

1.4 Missing Requirements

This document contains all EMWIN RF interfaces except those labeled "TBD" and "TBR". "TBD (To Be Determined) means that the contractor should determine the missing requirements in coordination with the government. The term "TBR" (To Be Reviewed) implies that the requirement is subject to review for appropriateness by the contractor or the government. The government may change "TBR" requirements in the course of the contract.

1.5 Definitions

The statements in this document are not of equal importance. The word "shall" designates a requirement. Any deviations from the requirements will require approval of the NASA contracting officer. The word "will" designates a statement of fact about the system, its operational environment or the intent of the government.

The word "threshold" is the minimum acceptable performance characteristic.

Rationale: MRD-2B, ID Item 1066

The word "goal" is an optimum level of performance, which, if met, could greatly enhance data utility.

Rationale: MRD-2B, Item 1067

2.0 EMERGENCY MANAGERS WEATHER INFORMATION NETWORK (EMWIN) AND INTERFACE DESCRIPTION

2.1 General Description

The Emergency Managers Weather Information Network (EMWIN) data will be transmitted from the NOAA Command and Data Acquisition Stations (CDAS) at Wallops, VA (or its backup) to the spacecraft for distribution to a large data user community. This system provides unidirectional broadcast link connectivity between the originating uplink from the CDAS and a large number of outlying ground EMWIN User Terminals (EUTs). Applicable Reference document [2] contains a description of the NOAA/NESDIS Antennas and RF system capabilities for the ground stations.

The GOES support to the EMWIN user terminals is provided by GOES-East at 75 degrees west longitude and the GOES-West satellite at 135 degrees [TBR] west longitude. The EMWIN link relays emergency management weather information from the CDAS, independently through the GOES-East and GOES-West satellites, and downlinks the information to EMWIN user terminals.

The EMWIN satellite transponder is a bent-pipe architecture, i.e., receiving the uplinks within a certain frequency band, translating to a new frequency band, amplifying, and retransmitting on the downlink, but with no other processing. For the EMWIN link, the uplink is S-Band and the downlink is at L-Band. The GOES-East and the GOES-West satellites each employ an earth coverage antenna for reception of the uplink EMWIN signals from the CDAS and an earth coverage antenna to provide downlink transmission at L-Band to the ground terminals. The EMWIN User Terminals may be anywhere in the earth coverage area of the satellite out to the design minimum elevation angle.

3.0 EMWIN RF INTERFACE REQUIREMENTS

3.1 General

The Emergency Managers Weather Information Network (EMWIN) is a unique data link that provides a service. The EMWIN transponder provides for the transmission of low data rate weather and other emergency related data from the CDAS to local Emergency Managers of the Federal Emergency Management Agency (FEMA).

Rationale: MRD-2B ID Item 4502.

The EMWIN service supports the widespread distribution of low data rate weather and other emergency related data from the CDAS to small receive only earth stations in the service of Local Emergency Managers of FEMA. Transmission is supported in the GOES-R satellite by a bent pipe transponder that must have the RF interface characteristics described in the following sections.

Rationale: MRD-2B ID Item 4503.

The EMWIN data link requirements summary is described in Table 3.1-1.

CDA Uplink Tx	**Requirement**	**Rationale**
EIRP (dBm)	[TBD]	
Frequency (MHz)	2037.700 [TBR]	MRD-2B, ID Item 4510 and CWG
Polarization	Linear N-S	Heritage spec. from GOES-N,O,P
Info. Data Rate (kbit/s)	56	ID item 4505 in MRD-2B
Tx Data Rate (kbit/s)	128	ID item 4505 in MRD-2B
RF Bandwidth (kHz)	160 kHz (approx., TBR)	ID item 4509 in MRD-2B
Format	NRZ-L	Heritage spec. from GOES-N,O,P
Modulation	QPSK	
FEC Code	Para. 3.2.4	
Satellite Rx		
Polarization	Linear N-S	
Cross Polarization Isolation (dB)	[TBD]	
Coverage	Para. 3.3.2	MRD-2B ID Item 4512
Min. Rx G/T (dB/K)	[TBD]	
Nominal Rx Sig. Level	[TBD]	
Dynamic Range	Nominal value ± 5 dB	Comm. working group
Satellite Tx		
Frequency (MHz)	1695.700 [TBR]	MRD-2B ID Item 4511 and CWG
Polarization	Linear N-S	Heritage spec. from GOES-N,O,P
EIRP (dBm)	53 [TBR]	Scaled from GOES-N measured data
Coverage	Para. 3.4.1	

FER	Para. 3.4.4	MRD-2B ID Item 4508
Ground Rx		
Polarization	Linear N-S	Heritage spec. from GOES-N,O,P
Min. Rx G/T (dB/K)	-0.3	Heritage spec. from GOES-N,O,P
Rx System Loss (dB)	3.0 [TBR]	Prototype receiver in development

Table 3.1-1 EMWIN Data Link Requirements Summary

3.2 CDA Uplink Interface Requirements

3.2.1 Frequency Stability

The long-term (1second and greater) frequency stability of the uplink signal will be maintained at ≤ 1 part in 10^9.

3.2.2 Phase Noise

The phase noise on the EMWIN data channel uplink will meet the mask given in Figure 3.2.2-1.

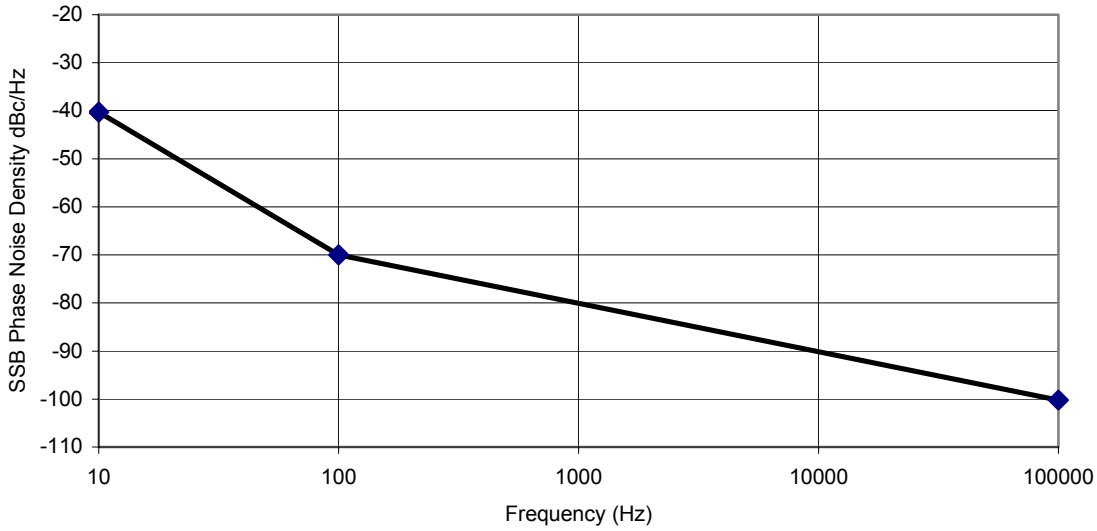

Figure 3.2.2-1 Phase Noise Specification

3.2.3 Square Root Raised Cosine Filter

A square root raised cosine (SRRC) filter will be incorporated in the EMWIN uplink channel hardware. The roll-off factor will be 1.0.

Rationale: The SRRC filter will be used to optimize the use of the bandwidth that is available.

3.2.4 Forward Error Correction

The forward error correction (FEC) that will be incorporated into the EMWIN uplink channel hardware is [TBD].

Discussion: The prototype EMWIN ground equipment is presently in a development phase. The EMWIN signal for GOES-N is 19.2 kbps, is expected to use QPSK modulation and rate ½ convolutional code and a Reed-Solomon (255, 223) FEC.

3.3 Satellite Receive Interface Requirements

3.3.1 Satellite EMWIN Data Channel

The Space Segment (SS) requirements consist of receiving the uplink S band signal, down-converting to L-Band and amplifying and transmitting this signal to the EMWIN User Terminals. There is no demodulation of the EMWIN signals on the satellite (i.e., 'bent-pipe' architecture)

3.3.2 Satellite Receive Antenna Coverage

The satellite antenna coverage shall be earth coverage to the minimum elevation angle of 5º.

3.4 Satellite Transmit RF Interface

3.4.1 Satellite Transmit Antenna Coverage

The downlink satellite transmit antenna coverage shall be earth coverage to the minimum elevation angle of 5º.

Rationale: The satellite transmit antenna coverage is a flow-down requirement from ID item 4513 in the MRD-2A Document..

3.4.2 Phase Noise

The downlink phase noise shall not exceed the mask given in Figure 3.2.2-1.

3.4.3 Unwanted Radiation Mask

All communication links must comply with paragraph 5.2.2, for frequencies less than 470 MHz and 5.6.2 for frequencies above 470 MHz, of the NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management, May 2003 Edition, September 2004 Revision.

3.4.4 Frame Error Rate Requirement

The required Frame Error Rate (FER) for the EMWIN data channel shall not be greater than $1X10^{-5}$ at 99.9 % availability, worst month (TBR).

Rationale: MRD-2B, ID Item 4508..

3.5 Ground Terminal Receive Interface Requirements

3.5.1 General

The ground terminal receive interface requirements summary for the EMWIN data link are described in Table 3.1-1. The EMWIN user terminals are L-band receive-only terminals.

3.5.2 EMWIN Terminal Phase Noise

The EMWIN receiver phase noise performance is similar to the specification described in Figure 3.2.2-1.

4.0 LINK PERFORMANCE SPECIFICATIONS

4.1 Link Requirements

The link calculations shall demonstrate link closure under the following assumptions.

1. The forward error correction code, described in Section 3.2.4, will be included in the uplink transmit signal.
2. A 0.25 dB [TBR] polarization loss shall be assumed for the uplink and a 0.25 dB (TBR) polarization loss assumed for the downlink.
3. Interference accesses shall be assumed small and no specific entry is required.
4. Propagation impairments are the rain and atmospheric attenuation loss of [TBD] on the uplink and the rain and atmospheric attenuation loss of [TBD] on the downlink. The rain and atmospheric attenuation estimates shall be based on the ITU models for CDAS and the back-up CDAS locations. The spacecraft contractor shall calculate the propagation impairments and present the data during the PDR. The data shall be incorporated into the ICD link budget following approval by GSFC.
5. The worst- case end-of-life link margin that shall be used in the link budget is 3 dB [TBR].
6. Applicable documents [3] thru [12] can be used in determining propagation attenuation, and reference [11] can be used for scintillation loss.

4.3 Radio Astronomy band protection

The EIRP values for the EMWIN data link shall protect the radio astronomy band from 1660 to 1670 Mz, so that the spectral power flux density in this band at the surface of the earth shall be ≤ -266 dB W/m^2 –Hz.

Rationale: Compliance is required with the power flux density requirement for the Radio Astronomy Band as described in the International Telecommunications Union (ITU) Recommendation ITU-R RA 769-1. The ITU specifies a maximum PFD at the ground of -251 $dBW/m^2/Hz$ for the RA band, and this level must be reduced by another 15 dB for geostationary satellites.

4.4 Power Flux Density Limit

The downlink EIRP for the EMWIN data link shall conform to the ITU regulations Section RRS21, Table S21-4 regarding Power Flux Density (PFD) at the surface of the Earth. The communication link shall comply for both the 1.5 MHz and 4 KHz bandwidth at L-Band. The spacecraft contractor shall notify GSFC if he determines that any transmission channel requires a higher than allowed EIRP to meet the communications data link performance requirements.

The PFD values for the EMWIN data link shall be defined by the spacecraft contractor and incorporated into the Interface Control Document (ICD) following the Preliminary Design Review and after approval by GSFC.

Rationale: The ITU regulations are described in Article S21 titled "Terrestrial and Space Services Sharing Frequency Bands above 1 GHz" of the ITU Radio Regulation RR-S21

4.5 Communications Link Budget Requirement

The spacecraft contractor shall provide the communication link budgets in the ICD for the EMWIN data link service.

Changes to the link Budget shall be documented and reported monthly to the GSFC Communications Subsystem Manager.

Rationale: There is a need to ensure adequate link margins prior to freezing the design and following the manufacturing of flight hardware.

APPENDIX A – ABBREVIATIONS AND ACRONYMS

AGC	Automatic Gain Control (functionally equivalent to ALC)
ALC	Automatic Level Control (functionally equivalent to AGC)
AM	Amplitude Modulation
AS	Archive Segment
β	Modulation Index
BCH	Bose-Chaudhuri-Hocquenghem (Forward Error Correction Code)
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
BW	Bandwidth or Beamwidth (context dependent)
C3S	Command, Control and Communications Segment
CDA	Command and Data Acquisition
CDAS	Command and Data Acquisition Station
CCSDS	Consultative Committee on Space Data Systems
C/N_0	Carrier to Noise Density Ratio (dB-Hz)
COSPAS	(Russian: Cosmicheskaya Sistyema Poiska Avariynich Sudov) Space System for the Search of Vessels in Distress
CP	Circularly Polarized or Circular Polarization
CWG	Communications Working Group

DCS	Data Collection System
E_b/N_0	Energy per bit to noise density ratio
EIRP	Equivalent Isotropically Radiated Power
EOC	Edge of Coverage
EUT	EMWIN User Terminal
EMWIN	Emergency Managers Weather Information Network
EPIRB	Emergency Position Indicating Radio Beacons
FEC	Forward Error Correction
GEOLUT	Geostationary Local User Terminal
GL-C3S	Ground Located C3 (Command, Control, and Communications) Segment
GOES	Geostationary Operational Environmental Satellite
GRB-F	GOES Rebroadcast - Full
GRB-L	GOES Rebroadcast - Lite
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
G/T	Gain-to-Noise Temperature Ratio (dB/K)
ICD	Interface Control Document
IEES	Intelsat Earth Station Standards
IRD	Interface Requirements Document
ITU	International Telecommunications Union
L-Band	1.0 – 2.0 GHz Frequency Band
LDBC	Low Density Parity Check
LEO	Low Earth Orbit
LHCP	Left Hand Circularly Polarized
LP	Linearly Polarized or Linear Polarization
LRIT	Low Rate Information Transmission
LSS	Launch Support Segment
LUT	Local User Terminal
MCC	Cospas-Sarsat Mission Control Center
MRD	Mission Requirements Document
NASA	National Aeronautics and Space Administration
NOAA	National Oceanographic and Atmospheric Administration
NTIA	National Telecommunications Information Agency
PGDS	Product Generation and Distribution Segment
PDR	Preliminary Design Review
PLB	Personal Locator Beacon

PM	Phase Modulation
PSK	Phase Shift Keying
RF	Radio Frequency
RHCP	Right Hand Circularly Polarized
RVTM	Requirements Verification Traceability Matrix
SARSAT	Search and Rescue Satellite-Aided Tracking
S-Band	2.0 – 4.0 GHz Frequency Band
SIS	Solar Imaging Suite
SEISS	Space Environment In-Situ Suite
SS	Space Segment
TBD	To Be Determined
TBR	To Be Reviewed
TBS	To Be Supplied
TRD	Technical Requirements Document
UHF	300 – 1000 MHz Frequency Band
UIS	User Interface Segment
USG	United States Government
X-Band	8 – 12 GHZ Frequency Band